

Comments and Response

Claims 1-14 and 29-63 stand rejected on various grounds. In view of the comments below Applicant respectfully requests that the Examiner reconsider the present application including rejected claims 1-14 and 34-63 and withdraw the rejections of these claims. Claims 29 - 33 have been cancelled. Claims 1, 3, 6, 9, 11, 13, 14, 34, and 38 have been amended with this amendment and response. No new matter has been added by the amendments to these claims.

a) Applicant notes with appreciation that the claim for priority under 35 U.S.C. §119 has been acknowledged and certified copies of priority documents have been received. In the Amendment and Response filed on February 24, 2003 and entered as part of the RCE of March 21, 2003, an Amended FIG 3B (adding a "Prior Art" caption) was included. The April 22, 2003 Office Action does not acknowledge the amended FIG 3B. Please advise whether the amended FIG 3B has been accepted.

b) Claims 1-50 stand rejected under 35 USC § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, to make and/or use the invention. Applicant respectfully notes that claims 15-28 have been previously cancelled without prejudice and that claims 29-33 are hereby cancelled thus rendering this rejection moot with respect to claims 15-33.

The Examiner maintains that: it is not disclosed that the gate electrode portion in the trench is located "such that the insulation film is located between the inner wall surface and the gate electrode" as recited, variously, by claims 1, 3, 34, and 38. In so far as Applicant can appreciate the Examiner's concerns, it appears that the Examiner is concerned with referring to the vertical boundary area between the regions 23, 22, 24 and the insulation region 27 as an inner wall surface. However, Applicant respectfully notes that the boundary has been consistently referred to as an inner wall surface or

inner surface wall throughout the specification (see for example page 25, line 5 and a plurality of the figures) and that from the perspective of one in the trench 46 it would reasonably appear as an inner wall surface. In any event since there is only one surface or boundary of interest in this passage that is clearly depicted in numerous figures Applicant is unable to see where there is any indefiniteness or enablement issue introduced by this terminology and thus Applicant respectfully requests that the Examiner withdraw this rejection of these claims.

The Examiner has suggested that further delineation of what is meant by "inner wall" in the claims would be sufficient to overcome this rejection. In the interest of avoiding undue argumentation, Applicant would be happy to consider any specific suggestions the Examiner may have as to how this terminology could be clarified.

c) Claims 1, 2, and 29 stand rejected under 35 USC §102 as being anticipated by Applicants admission with the examiner referring to page 2 and 3 and FIG. 3B and 22B. Applicant has hereby cancelled claim 29 thus rendering this rejection moot with respect to this claim. Based on this, the Examiner construes FIG. 3B to show "said impurity concentration profile of said second conductivity type region changes gently in the depth direction of the semiconductor substrate (cf. Figure 3B) and wherein said impurity concentration profile of said second conductivity type region, resulting from impurities of a second conductivity type has a gentle peak at a depth greater than a junction depth of said first conductivity type region within said second conductivity type region, by virtue of the partial cancellation of n- and p- dopants near the interface of regions 3 and 4 (see Figure 3B) and the monotonically decreasing As and B dopant concentrations;". Applicant further notes with appreciation the Examiner's comments at page 3 regarding a better definition of impurity profile such that the profile is constrained to the p type impurities.

Applicant respectfully notes that regions 3 and 4 are elements shown in FIG. 20 and FIG. 22 with the corresponding dopant concentration depicted in FIG. 21. FIG. 21 shows net dopant concentration, e.g. with n and p dopants offsetting near boundary

regions. FIG. 3B shows the respective p type (B) and n type (As) dopant concentrations. From FIG. 3B the p type distribution of the prior art is reduced or lowered with depth with a single peak in the concentration located at the surface. In stark contrast FIG. 3A shows respective exemplary n type and p type concentrations with the p type concentration exhibiting a plurality of peaks levels with one near the surface and another gentle peak deeper than the junction between the As (n type) and B (p type) regions.

Claim 1 has been amended in view of the above comments to further clarify the impurity concentration profile of the second conductivity type diffusion region. Claim 1 now recites:

“ ... a second conductivity type diffusion region, having an island shape, formed at[on] the principal surface of said semiconductor substrate, wherein the second conductivity type diffusion region has an impurity concentration profile resulting from impurities of a second conductive type in a depth direction of the semiconductor substrate;

a highly doped first conductivity type region formed inside said second conductivity type diffusion region wherein said impurity concentration profile of said second conductive type impurity has a plurality of peaks at different depths in the depth direction of the semiconductor substrate such that a gentle peak is formed at a depth that is greater than a junction depth of said first conductivity type diffusion region; ...”

Applicant respectfully submits that the amended claim language succinctly captures the distinction between the Prior Art of FIG. 3B and the claimed distributions generally depicted in FIG. 3A. For these reasons Applicant respectfully submits that the Prior Art discussions does not show or suggest the invention as claimed by claim 1. Therefore Applicant respectfully requests that the Examiner reconsider and withdraw this rejection of claim 1 and by virtue of dependency claims 2.

d) Claims 34-42 and 51-55 stand rejected under 35 U.S.C. §102(e) as being anticipated by Huang (6,110,799). The Examiner maintains that Huang anticipates all recited elements of claim 34. Specifically, referring to Huang FIG. 11 and col.2, lines 38-43, the Examiner maintains that Huang shows “a second trench extending into but

not through the second conductivity type region and positioned away from the first trench.” Applicant respectfully notes that, in Huang, the trench 34 of FIG. 8, 9, and 12-14 clearly extends into the substrate or first conductivity layer 10 rather than extending into but not through the second conductivity region as in the present application (see 43 in FIG 8G, for example). FIG. 11 of Huang does not clearly show what the relationship between the trench (36) and the p layer 14 may be nor is there any discussion clarifying the relationship. It may be that the trench ends before the p layer 14 or not as the figure, unlike all other figures in the reference is not clear. Applicant respectfully submits that this is not a teaching of the claimed limitation sufficient for a good faith showing of anticipation.

Next, as in the previous office action the Examiner repeats the concept of construing what the reference Huang teaches, namely a buried p+ region 35 as two separate and distinct regions namely a deep p region surrounding a p+ region or as recited by claim 34:

“a second conductivity type protrusion region having a junction depth that is greater than the junction depth of the second semiconductor layer, the protrusion region being positioned beneath the second trench; and

a second conductivity type doped region that has an impurity concentration higher than that of the protrusion region, wherein the second conductivity type doped region has a diffusion depth that is less than the junction depth of the protrusion region, the second conductivity type doped region is positioned beneath the second trench, and the protrusion region encompasses the second conductivity type doped region;”

Applicant respectfully disagrees. There is no indication or suggestion in any of the references or specifically in Huang that the buried layer 35 is two layers. As indicated in the amendment originally filed on Feb. 24, 2003 and subsequently on Mar. 21, 2003 as part of the RCE filing, not only is the single p+ layer 35 of Huang structurally distinct from the claimed two layer structure, there are performance or quality differences that directly result from this difference in structure. For these reasons including the detailed reasons in the Mar. 21, 2003 amendment, Applicant respectfully submits that Huang (6,110,799) does not show or suggest the invention as claimed by claim 34 and by virtue of dependency claims 35-37. Therefore Applicant

respectfully requests that the Examiner reconsider and withdraw this rejection under 35 U.S.C. §102(e) of claim 34 and dependent claims 35-37 based on Huang (6,110,799).

Regarding claim 38, the Examiner maintains that “ a second conductivity type island located on the first semiconductor layer and adjacent to the second semiconductor layer of the trench MOS structure, the second conductivity type island being isolated from the second semiconductor layer and being in an electrically floating state” is shown by Huang, referring to FIG. 8 and 9 as the portion of 14 to the left of the left most trench (20 in FIG 3). Applicant respectfully notes that this portion of 14 is beyond the active area for the structure of Huang as defined by the mask 12 (see col. 2, lines 1-5) and further that Huang is silent on the structure or whether it is electrically floating or what it may be connected to or what purpose it may serve. While the cross sectional diagrams of Huang with their limited perspective and information may suggest that this portion of 14 is electrically floating (e.g. mask 12 and layer 24) this is basically speculation on the part of the Examiner. Thus as previously noted it is simply unclear what the status of the area of 14 to the left of the left most trench may be or whether it is electrically floating or whatever as Huang is silent.

The floating island as claimed is shown in one embodiment in the plan view of FIG. 11 of the present disclosure. As depicted the portion of p type layer 43 between alternate adjacent gates 48 in the cross sectional view of FIG. 10 (e.g. two right most trenches and gates 48 is enclosed and thus isolated from the second semiconductor layer 43 between two left most trenches of FIG 10 by this trench within which gate 48 is formed. The amendment to claim 38, specifically, “ ...the second conductivity type island being isolated from the second semiconductor layer by said first trench and being in an electrically floating state;” further clarifies this matter. For these reasons Applicant respectfully submits that Huang (6,110,799) does not show or suggest the invention as claimed by claim 38 and by virtue of dependency claims 39-42. Therefore Applicant respectfully requests that the Examiner reconsider and withdraw this rejection under 35 U.S.C. §102(e) of claim 38 and dependent claims 39-42 based on Huang (6,110,799).

Regarding claim 51 as noted in the earlier Mar. 21, 2003 amendment and repeated here, the Examiner essentially maintains a similar construction of Huang and believes the portion of 14 and 16 to the left of the left most trench anticipate the claimed a second portion of the second semiconductor layer and a second doped region of a first conductivity type located inside the second portion and proximate to the opening of the first trench wherein the second doped region and the second portion of the second trench MOS structure are in an electrically floating state. Applicant notes that these regions of Huang are not part of the active area of the Huang structure nor are they discussed nor are we provided any other information in the Huang reference that allows any more than speculation as to the electrical isolation or otherwise of this structure as discussed immediately above.

For these reasons Applicant respectfully submits that Huang (6,110,799) does not show or suggest the invention as claimed by claim 51 and by virtue of dependency claims 52-55. Therefore Applicant respectfully requests that the Examiner reconsider and withdraw this rejection under 35 U.S.C. §102(e) of claim 51 and dependent claims 52-55 based on Huang (6,110,799).

e) Claims 3-5 and 30 stand rejected under 35 U.S.C. §103(a) as being unpatentable over the Prior Art as disclosed by Applicants in view of Huang (6,110,799). Claim 30 has been cancelled thus rendering this rejection moot as to that claim. Claim 3 has been amended to read as follows:

A semiconductor device comprising:

a semiconductor substrate having a first conductivity type layer at a principal surface and a second conductivity type layer at a rear surface [principal surface of a first conductivity type];

a second conductivity type diffusion region formed at[on] the principal surface of said semiconductor substrate;

a highly doped first conductivity type region formed inside said second conductivity type diffusion region;

a plurality of first trenches, each extending from a surface of said highly doped first conductivity type region through [to reach at least]said second conductivity type diffusion region

to[on] said first conductivity type layer of said semiconductor substrate, thereby defining a channel portion on an inner wall surface of each of the first trenches;

an insulation film formed on the inner wall surface of each of the first trenches;

an electrode portion made of polycrystalline silicon filling each of the first trenches such that said insulation film is located between said electrode portion and said inner wall surface;

a plurality of second trenches formed to extend into but not through said second conductivity type diffusion region so that each of the second trenches is positioned between an adjacent pair of said first trenches;

a second conductivity type protrusion region, which protrudes downwardly, wherein the second conductivity type protrusion region forms a junction that is deeper than a junction of said second conductivity type diffusion region, the protrusion region being positioned beneath the second trench; and

a second conductivity type highly doped region having an impurity concentration higher than that of the protrusion region, wherein the depth of the second conductivity type highly doped region is less than that of the junction of said protrusion region, the second conductivity type highly doped region is located beneath the second trench, and wherein the protrusion region encompasses the second conductivity type highly doped region.

As noted above with regard to claim 34 the second trenches 34 shown by Huang are not limited to the second conductivity type region 14 but rather extend to the substrate 10 (see Huang FIG. 8-9). As noted above it is not clear what the relationship between the second trenches and the second conductivity type region 14 may be in FIG. 11 of Huang. As also noted and for the reasons indicated with reference to claim 34, Applicant does not believe or agree with the Examiner's view that the second conductivity type protrusion region 73 and the second conductivity type highly doped region 74, each as claimed, are shown or suggested by the buried layer 35 of Huang. Since the Prior Art as known to Applicant and the references that have been cited, specifically Huang, do not whether taken alone or in combination show all elements of claim 3 as noted here and in further detail above with reference to claim 34, Applicant respectfully submits that claim 3 and claims dependent thereon, specifically 4-5 as well as 6-10, have not been rendered unpatentable under 35 U.S.C. §103(a). Thus Applicant respectfully requests that the Examiner reconsider claims 3-5 and withdraw this rejection.

f) Claims 6-10 and 31-32 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Prior art as admitted by Applicants over Huang as applied to claim 3 above, and further in view of Yu et al (6,213,869 B1). Claims 31-32 have been cancelled and thus this rejection of those claims is rendered moot. As discussed above Applicant believes claim 3 is allowable over Prior Art as disclosed by Applicants in view of Huang (6,110,799). The Yu reference does not show or suggest taken alone or together with the other reference material the limitations of independent claim 3 and thus claims 6-10 are believed to be allowable.

Furthermore claim 6 as amended recites:

The semiconductor device according to claim 3, further comprising a portion of the second conductivity type diffusion region disposed between an adjacent pair of the first trenches, where the second trenches are not formed, wherein the portion is in an electrically floating state.

Applicant respectfully submits that Yu et al. does not disclose or suggest such a structure taken alone or together with the other references and thus does not teach or suggest the further limitations of claim 6.

Claim 7 recites The semiconductor device according to claim 3, further comprising:

a first electrode provided in one of said second trenches for electrically connecting the second conductivity type protrusion region to the highly doped first conductivity type region through the one of the second trenches;

a second electrode provided in another one of said second trenches for electrically connecting the second conductivity type protrusion region to the highly doped first conductivity type region through the another one of the second trenches, the second electrode being disposed adjacent to the first electrode;

wherein one of adjacent pair of the first and second electrodes is in an electrically floating state.

Applicant respectfully submits that Yu et al. does not disclose or suggest such a structure taken alone or together with the other references and thus does not teach or suggest the further limitations of claim 7.

For the above reasons Applicant respectfully requests that the Examiner reconsider and withdraw this rejection of claims 6-10.

g) Claims 11-14 and 33 are rejected under 35 U.S.C. §103(a) as being unpatentable over Prior Art as admitted by Applicants in their disclosure (pages 2-3 and Fig. 22B) in view of So et al (5,895,951). Claim 33 has been cancelled thus rendering this rejection moot as to that claim. Claim 11 has been amended to depend from claim 3 and claims 12-14 each depend from claim 11. As detailed above, Applicant believes that claim 3 is allowable over prior art and the Huang reference. So et al. does not supply the missing teachings. These claims depend from claim 3 and thus by virtue of dependency should also be allowable.

Furthermore claim 11 recites:

The semiconductor device according to claim 3, further comprising: a plurality of electric field alleviating regions of the second conductivity type formed in a strip-wise shape so as to enclose a peripheral portion of said second conductivity type diffusion region.


Applicant respectfully submits that So et al. does not disclose or suggest such a structure (e.g. strip wise shape enclosing a peripheral portion ...) taken alone or together with the other references and thus does not teach or suggest the further limitations of claim 11. Thus and for these reasons Applicant respectfully requests that the Examiner reconsider and withdraw this rejection of claims 11-14.

h) Claims 35-36, 43-50 and 56-63 are rejected under 35 U.S.C. §103(a) as being unpatentable over Huang (6,110,799) in view of Prior art as admitted by applicant. As discussed above it is believed that independent claims 34, 38, and 51 are allowable over the references of record. Each of these claims depend from one of claims 34, 38, and 51 and by virtue of dependency should likewise be allowable. Thus Applicant respectfully requests that the Examiner reconsider and withdraw this rejection of these claims 35-36, 43-50 and 56-63 under 35 U.S.C. §103(a) based on these references.

Accordingly, Applicant respectfully submits that the claims, as amended, clearly and patentably distinguish over the cited reference of record and as such are to be deemed allowable. Such allowance is hereby earnestly and respectfully solicited at an early date. If the Examiner has any suggestions or comments or questions, calls are welcomed at the phone number below.

Although it is not anticipated that any fees are due or payable, other than the petition fee for a one month extension of time, the Commissioner is hereby authorized to charge any fees that may be required to Deposit Account No. **50-1147**.

Respectfully submitted,

A handwritten signature in dark ink, appearing to read 'DGP', is written over a horizontal line.

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